

# Augmentative Release of Parasitoid Wasps in Stored Wheat Reduces Insect Fragments in Flour

Paul W. Flinn and David W. Hagstrum  
Grain Marketing and Production Research Center, USDA-ARS, Manhattan, KS

## Introduction

Biological control is an overlooked component of integrated pest management of stored grain. Most of the parasitoids that attack the primary beetle pests are in the families Pteromalidae and Bethyliidae. These hymenopterous parasitoids are very small (1-2 mm), and do not feed on the grain. They will normally die within 5 to 10 days if no beetles are present in the grain. These parasitoids are found naturally in stored grain, which suggests that once released they may continue to suppress pests for many years. Because the adult wasps are external to the grain, they can easily be removed from it using normal cleaning processes.



The lesser grain borer, *Rhyzopertha dominica* (F.), is one of the most common and damaging insect pests of stored wheat in the United States. Adults feed primarily on the wheat endosperm and cause considerable damage. *R. dominica* larvae develop within the grain kernel and cannot be removed from the grain by normal cleaning procedures.



*Theocolax elegans* (Westwood) is a small pteromalid wasp that attacks the coleopterans *R. dominica*, *Sitophilus* spp., *Stegobium paniceum* (L.), *Callosobruchus* spp., and the lepidopteran, *Sitotroga cerealella* (Oliver). This wasp normally parasitizes larvae that are feeding inside the grain kernel. Although wasp larvae can complete development on 3rd instar and prepupal *R. dominica*, larval survivorship is highest when laid on 4th instar *R. dominica*. They normally lay 1 egg externally on each host (Sharifi 1972). At 32°C, it takes about 15 days to complete development on *R. dominica*. The generation time of this wasp is about half that of *R. dominica*. If hosts are available, female wasps live for 10 to 20 days at 32°C. A single female *T. elegans* can parasitize up to 6 *R. dominica* per day.

The big question, about using these wasps to suppress pest insects in stored grain, is whether the wasps will increase or reduce insect fragment counts in flour that is milled from the grain.

## Materials and Methods

Six cylindrical bins, 4.72 m diameter by 3.35 m tall at the eaves, were constructed so that they were air-tight, except for 2 roof ventilation ports that were covered with 80 mesh screen. Each of the 6 bins was filled with 27.2 T (1000bu) of insect-free wheat.

On 6 July 1993, 270 1-wk-old *R. dominica* and 270 1-wk-old *C. ferrugineus* adults were released on the grain surface of each of the 6 bins. The same number of beetles were released at monthly intervals up to 6 October to simulate beetle immigration, for a total of 4 releases.

Adult parasitoids were released into 3 of the 6 bins 21 d after initial beetle infestation. Based on simulations with a model (Flinn and Hagstrum 1995), 21 d from storage was found to be the best time to start parasitoid releases. Five hundred forty *C. waterstoni* adults and 540 *T. elegans* adults (all < 3 d old) were added to 3 of the 6 bins on 27 July. The sex ratio of both species of wasps was » 2:1 female:male. Two additional parasitoid releases were made in

the same bins at weekly intervals.

In the 1994 study, the 6 bins were each filled with 27.2 T of wheat. In this second field study, we wanted to determine if the wasps could control higher densities of beetles, so we released twice the number of beetles that were used in the first study. We released 540 *C. ferrugineus* and 540 *R. dominica* into the bins at monthly intervals starting 7 July up to 7 October, for a total of 4 releases. On 28 July 1994, 700 *C. waterstoni* and 2160 *T. elegans* were released into each of the three treatment bins. On 4 August 1994, we released 1080 *C. waterstoni* and 2160 *T. elegans*, and on 8 September 1994 we released 1600 *C. waterstoni* and 2160 *T. elegans* into each of the 3 treatment bins.

Grain sampling was conducted at monthly intervals using a pneumatic grain sampler (Probe-A-Vac, Cargill Inc., Minneapolis Minnesota). Seven 3-kg samples in each of the 3 66.6 cm layers of wheat were taken at 3 points near the center of the bin and at 4 points 2/3 the distance between the center and the outer wall. Control bins were sampled 1st to minimize accidental introduction of parasitoids into these bins. Samples were immediately placed in plastic containers. Grain samples were processed over an inclined sieve (89 by 43 cm, 1.6 mm aperture). Adult insects were identified and counted (live and dead determined).

We used samples from the final sampling date to estimate insect fragments in flour and insect damaged kernels (IDK). The grain samples were cleaned by sieving, then the wheat was milled using a Brabender Quadrumat Senior. Insect fragments were counted by an official FGIS technician using the acid hydrolysis method. We also used a commercial ELISA method which detects insect muscle protein (myosin) in samples (Biotect, Austin TX).

## Results and Discussion

Because of space constraints, we will show only the population dynamics of *R. dominica* and not *C. ferrugineus*. Unlike *C. ferrugineus*, *R. dominica* completes its development inside the wheat kernel, and therefore is more likely to contribute to insect fragments in flour.

In the 1993 Field Study, the 3 bins with parasitoids added to them had much lower densities of *R. dominica* than the control bins (Fig. 1). On the last 3 sample dates, the control bins averaged 2.0 *R. dominica*/kg and the treatment bins averaged 0.2 *R. dominica*/kg. Thus, *R. dominica* populations in the treatment bins were suppressed 88% compared to the controls.

In the 1994 study the 3 bins with parasitoids added to them had much lower densities of *R. dominica* than the control bins (Fig. 2). *Rhyzopertha dominica* densities in the treatment and control bins were 7/kg and 81/kg, respectively, 131 days after the start of the experiment. Thus, *R. dominica* populations in the treatment bins were suppressed 91% in comparison to the control bins. The experiment was stopped after 131 days because of the very high *R. dominica* density in the control bins

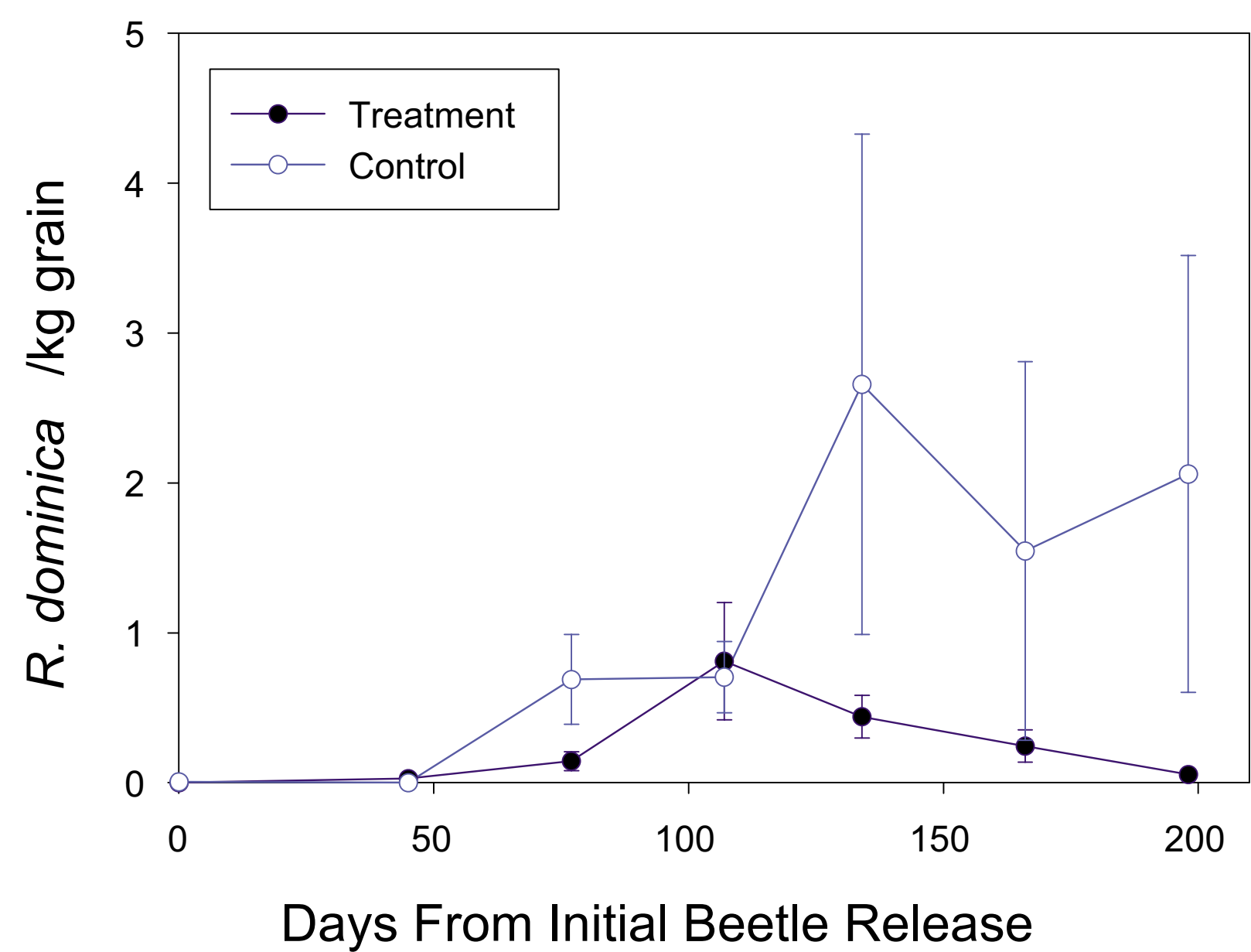


Fig. 1. 1993 average *Rhyzopertha dominica* density in 3 control bins, and in 3 bins in which the parasitoid *Theocolax elegans* was released. Vertical bars indicate standard error of the mean.

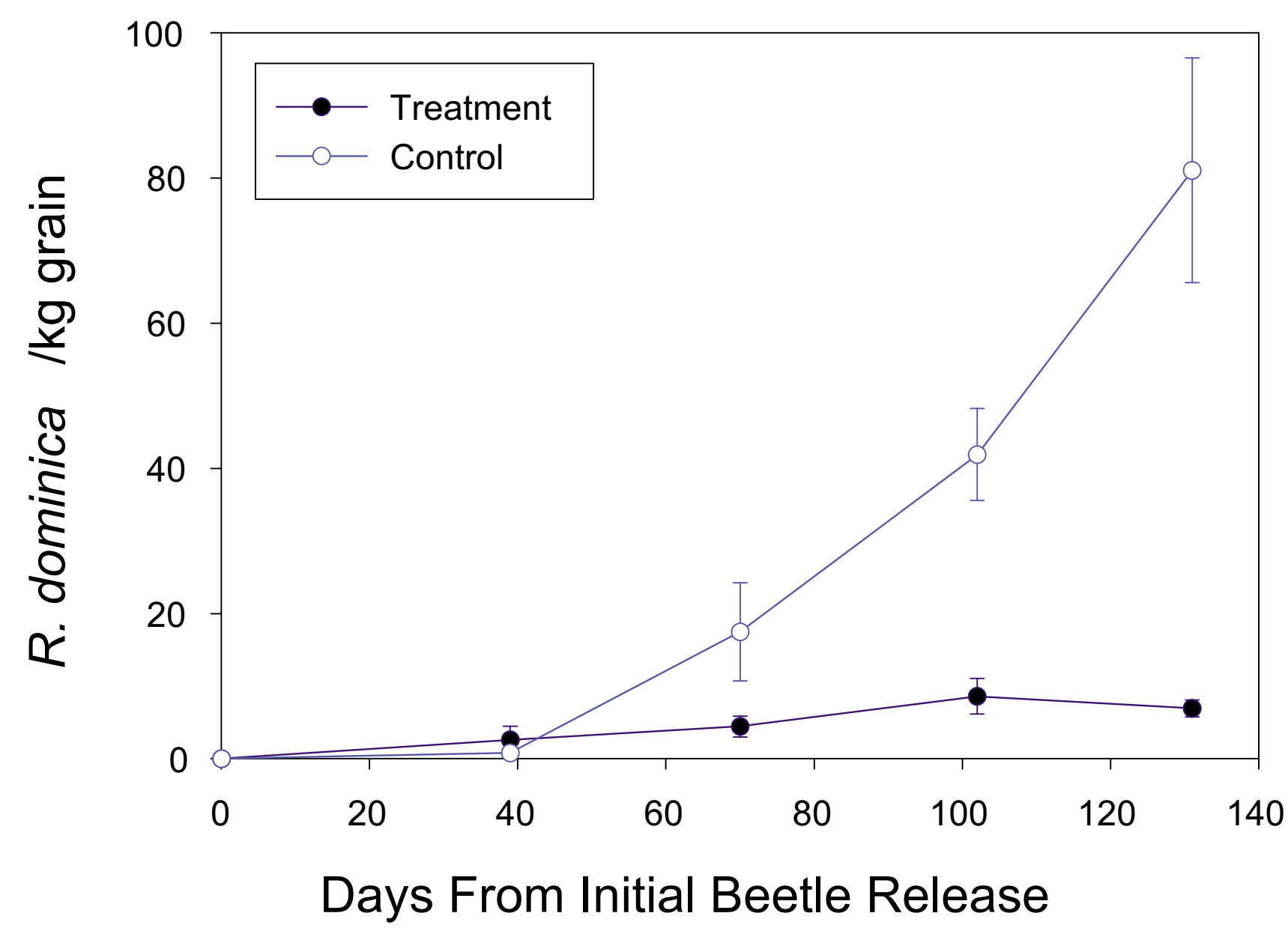


Fig. 2. 1994 average *Rhyzopertha dominica* density in 3 control bins, and in 3 bins in which the parasitoid *Theocolax elegans* was released. Vertical bars indicate standard error of the mean.

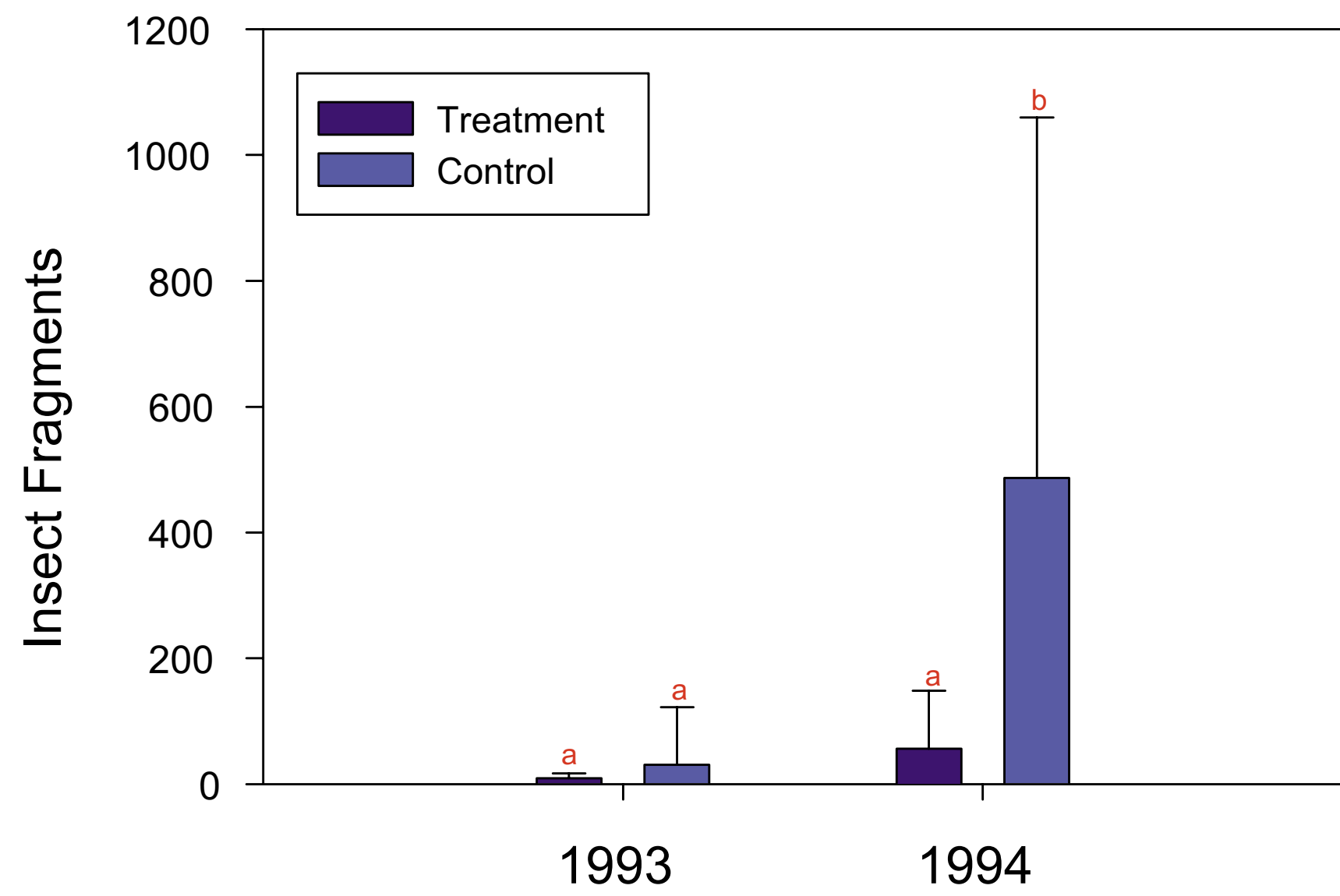


Fig. 3. Mean number of insect fragments in 50 g flour samples milled from wheat obtained from treated and control grain bins. Vertical bars indicate SEs of the mean. Within years, means with different letters are significantly different (p<0.05).

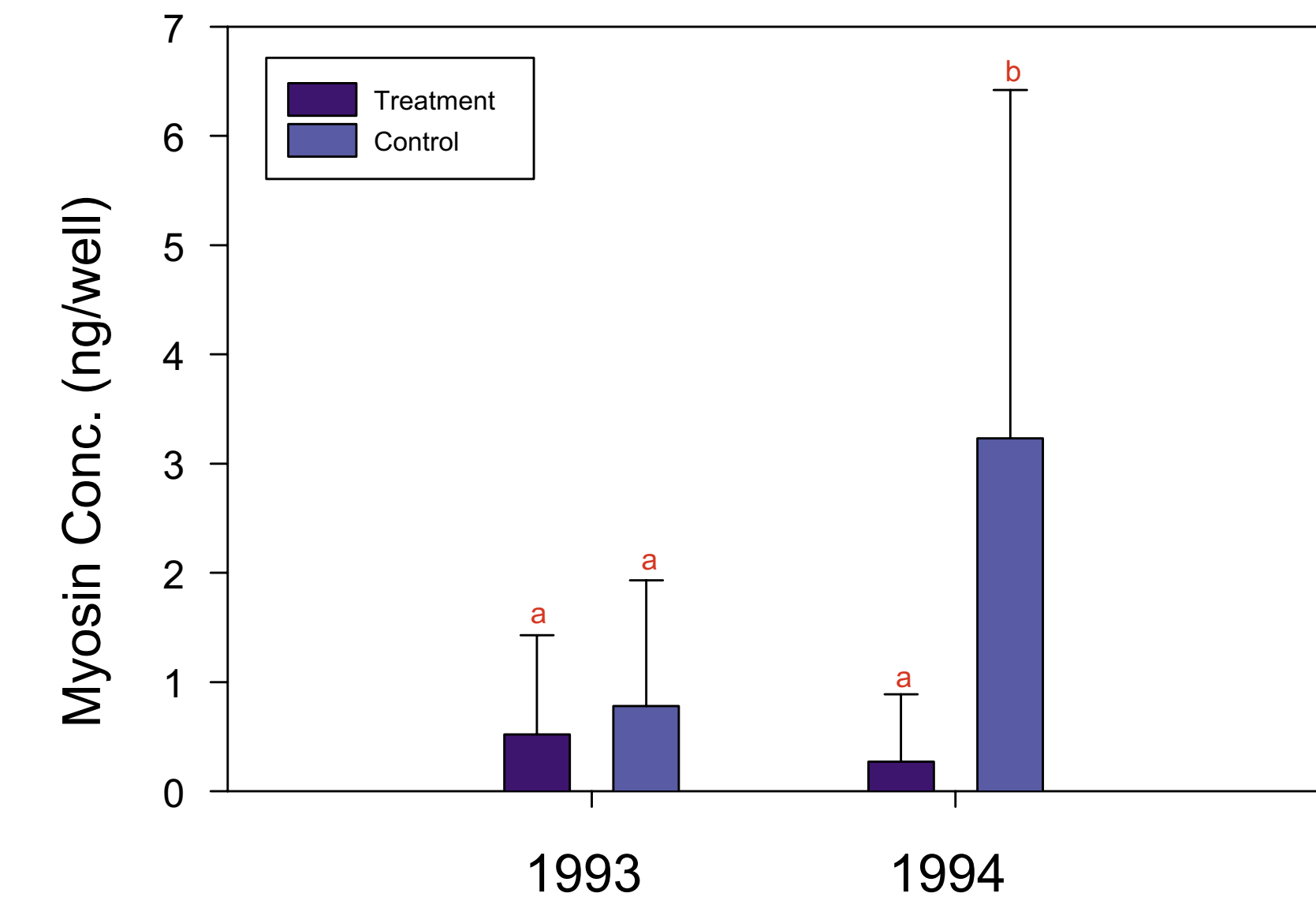


Fig. 4. Mean insect muscle protein (myosin) concentration (ng/well) from flour samples milled from wheat kernels obtained from treated and control grain bins. Vertical bars indicate SEs of the mean. Within years, means with different letters are significantly different (p<0.05).

In general, the number of insect fragments per sample were much lower in the treated than in the control bins in 1993 and 1994 (Fig. 3). In 1993, fragment counts were 9.4 and 31 in the treatment

and control bins. However, these differences were not significantly different. In the 1994 study, fragment counts averaged 56 and 487 in the treatment and control bins. Thus, insect fragments were reduced by about 88% in 1994. Similarly, insect muscle protein (myosin) was much lower in the treated than in the control bins (Fig. 4). However, in 1993 the differences between treatment and control were not significantly different. The percentage reduction in myosin between the treatment and control was 92% in 1994. Myosin is a better indicator of insect contamination because it is less variable than insect fragment counts (the number of fragments an insect breaks up into is variable, plus there is often human error in counting fragments).

The number of insect damaged kernels (IDK) was significantly higher in the control than in the treatment bins in both years (Fig. 5). In 1993, IDK/100g wheat was about 6 and 15 in the treatment and control bins (percent reduction was about 61%). In the 1994 study, IDK was 12 and 148 (percent reduction about 92%). IDK is an important factor that determines whether grain will be rejected by an elevator or mill. In general, counts greater than 32 IDK/100g of wheat can result in rejection.

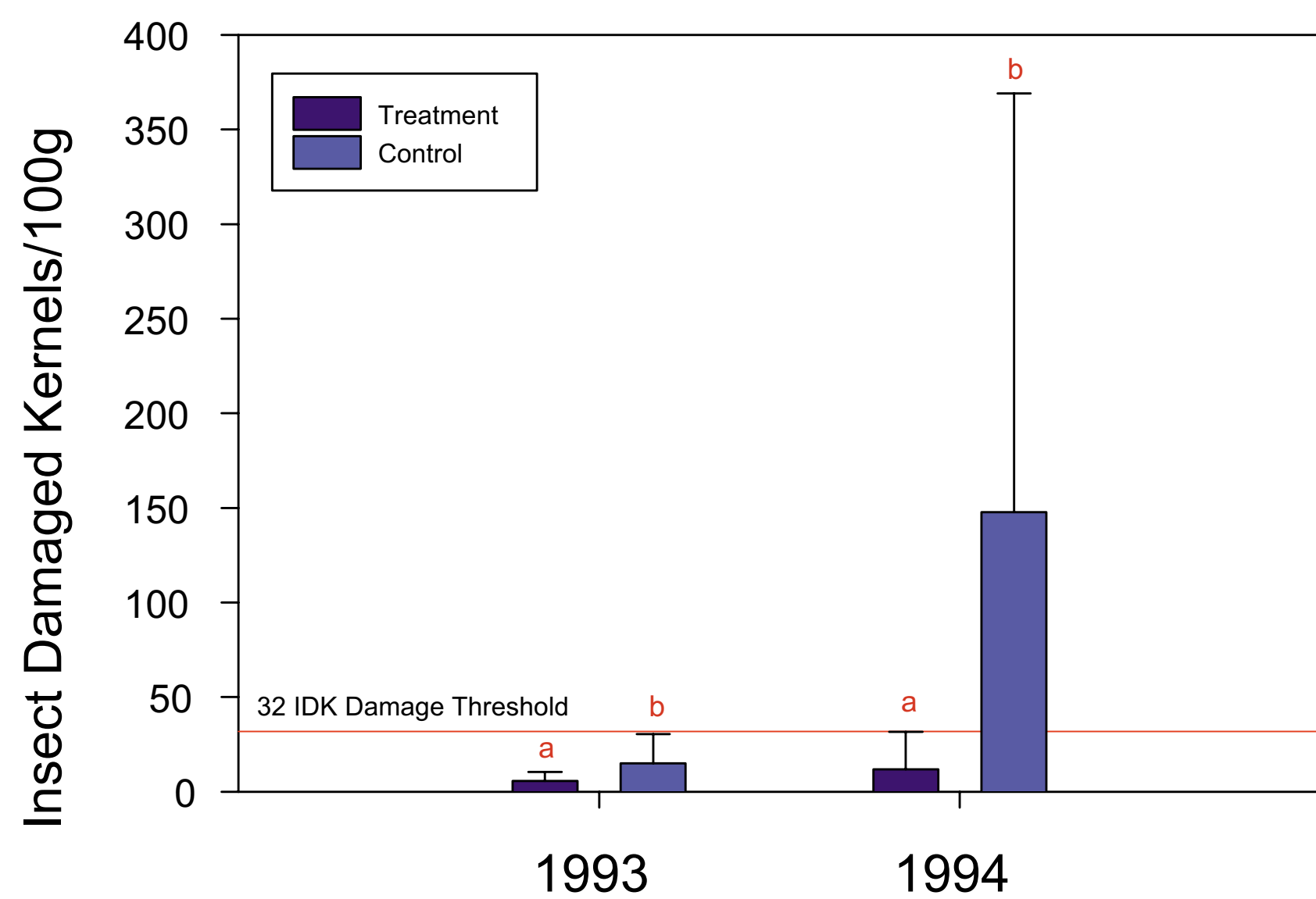


Fig. 5. Mean number of insect damaged kernels per 100 g of wheat obtained from treated and control grain bins. Red line indicates the damage threshold. Vertical bars indicate SEs of the mean. Within years, means with different letters are significantly different (p<0.05).

## Summary

Field studies were conducted to assess the effectiveness of the parasitoid wasp, *Theocolax elegans* (Westwood) for controlling *Rhyzopertha dominica* (F.) (lesser grain borer) and *Cryptolestes ferrugineus* (rusty grain beetle) in 6 bins, each containing 27 tons of wheat. We also investigated the effects of parasitoid augmentation on insect fragment counts in flour that was milled from the grain samples. Beetles were released at monthly intervals into all 6 bins. Parasitoid wasps were released into 3 of the bins.

Adult populations of *R. dominica* were reduced by about 90% compared to the control. *R. dominica* larvae develop inside wheat kernels and were probably the main source of insect fragments in the flour. In 1994, insect fragment counts were significantly lower in samples that came from bins in which parasitoids were released than in the control bins. Because of a relatively low infestation rate, fragment counts were not significantly different in 1993.

Insect myosin (a better indicator of insect contamination than fragments) followed the same trends as insect fragments. In 1994, insect myosin was significantly lower in flour samples from the treatment compared to the control bins.

The number of insect damaged kernels (IDK) was significantly lower in the treatment than in the control bins in both 1993 and 1994. In the control bins, the IDK level was above the FGIS threshold in both 1993 and 1994. This study showed that augmentative parasitoid releases do not increase the number of insect fragments in flour. On the contrary, the number of insect fragments was greatly reduced in flour milled from bins that were treated with parasitoid wasps compared to the control bins.